OE FORM 6000, 2/69

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ERIC REPORT RESUME

ERIC ACC. NO. ED 034 912				
CH ACC. NO. AA 000 477	P.A.	PUBL. DATE Sep 69	ISSUE RIEMAY70	

IS DOCUMENT COPYRIGHTED? YES ☐ NO ☒
ERIC REPRODUCTION RELEASE? YES ☐ NO ☒
LEVEL OF AVAILABILITY I ☒ II ☐ III ☐

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TITLE
Science Education Information Reports, Occasional Paper Series, Science Paper 1, Inservice Education for Teachers of Secondary School Science.

SOURCE CODE
RUF67410

INSTITUTION (SOURCE)
Ohio State University, Columbus, ERIC Information Analysis Center for Science Education

SP. AG. CODE

SPONSORING AGENCY

EDRS PRICE
0.25;2.75

CONTRACT NO.

GRANT NO.

REPORT NO.

BUREAU NO.

AVAILABILITY

JOURNAL CITATION

DESCRIPTIVE NOTE
53p.

DESCRIPTORS
*Inservice Teacher Education; Program Descriptions; *Research Reviews (Publication); Research Needs; Research Utilization; Secondary School Science; *Science Teachers; Science Institutes

IDENTIFIERS

ABSTRACT

This paper is the first of a series of occasional papers to be released through the ERIC Center for Science Education designed to report to the profession on various aspects of science education. The author reviewed three document types dealing with inservice education for secondary school science teachers. These were (1) published descriptions of inservice programs, (2) evaluative reports and studies of inservice programs, (3) research studies relevant to inservice education for science teachers. The documents reviewed were all published since 1960. The reports and studies reviewed can be classified into four general groups: National Science Foundation (NSF) institute programs, locally developed programs, cooperative college-school programs, and research and/or evaluative studies. The author summarized the studies reviewed and made some recommendations on the topics of (1) local inservice programs, (2) teacher attitudes, behaviors, and characteristics, (3) areas of needed research, and (4) research designs and evaluation. (RR)

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OCCASIONAL PAPER SERIES - SCIENCE
PAPER 1 - INSERVICE EDUCATION FOR TEACHERS OF SECONDARY SCHOOL SCIENCE

by

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September, 1969

ED 034 912

SCIENCE EDUCATION INFORMATION REPORTS

The Science Education Information Reports are being developed to disseminate information concerning documents analyzed at the ERIC Center for Science Education. The Reports include five types of publications. General Bibliographies are being issued to announce most documents processed by the Center for Science Education. These bibliographies are categorized by topics and indicate the availability of the document and the major ideas included in the document. Special Bibliographies are being developed to announce availability of documents in selected interest areas. These bibliographies will list most significant documents that have been published in the interest area. Guides to Resource Literature for Science Teachers are bibliographies that identify references for the professional growth of teachers at all levels of science teaching. This series will include six separate publications. Occasional Papers will be issued periodically to indicate implications of research for science and mathematics teaching. Research Reviews will be issued to analyze and synthesize research related to science and mathematics education over a period of several years.

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Robert W. Howe
and
Stanley L. Helgeson
Editors

INSERVICE EDUCATION FOR TEACHERS OF SECONDARY SCHOOL SCIENCE

INTRODUCTION

This paper is another in a series of reports to the profession concerning various aspects of science education. It is designed to supplement the previous review of research on preservice education for secondary school science teachers (12).

Inservice education is defined, in the Encyclopedia of Educational Research (34), as consisting of "all school-personnel activities which are designed to increase professional competence." This report is limited to three broad topics: published descriptions of inservice programs, evaluative reports and studies of inservice programs, and research studies relevant to inservice education for science teachers. In addition, a final section of the report contains recommendations for the improvement of inservice education programs and activities. The materials reviewed for this paper are limited to those studies, reports, and articles published since 1960.

In a previous review of research (12), the statement was made that science educators have assumed that the prime concern of preservice programs should be that of producing an effective, competent teacher who can help children learn. This same concern carries over into inservice programs and activities. It has been suggested that no sharp distinction be made between preservice education and inservice education. Instead, the two should merge as "continuing education" (54, 66). The fact that preservice education can provide the teacher with only the basic tools and skills of teaching means that inservice education is of primary importance in attaining the goal of producing individuals who can provide maximum learning opportunities for students.

The major emphasis in inservice education for science teachers has been on improving the teacher's background in science content and/or up-dating this information. There are problems in addition to the rapid obsolescence of subject matter knowledge and skills. These might be enumerated as (2) the proliferation of educational hardware, (3) the fluid but apparently evolving state of learning and instructional theory, (4) the advent of new educational tasks, such as education of the disadvantaged, (5) a growing necessity for global awareness, (6) the acceleration of school reorganization, (7) the increasingly evident consequences of teacher misassignment, and (8) the problem of teacher drop-outs (66). All of these problems carry implications for a broader perspective of inservice education activities for secondary school science teachers.

PROGRAM DESCRIPTIONS

This portion of the paper contains program descriptions and reports of inservice activities. These range from locally initiated and developed programs through those of curriculum projects and commercial publishers. Programs funded by the National Science Foundation (Inservice Institutes, Summer Institutes, Academic Year Institutes, Cooperative College-School Science Programs) are also included.

Cooperative College-School Science Programs (National Science Foundation)

An overview of the NSF Cooperative College-School Science Programs may be obtained by reading articles such as the one which appeared in the March, 1968, issue of School Science and Mathematics (55). In it were listed 81 grants to help school systems improve science and mathematics courses and curricula. Most of these concentrated on a specific discipline although some were oriented toward introducing new curriculum materials.

Higgins and Boyer (38) reported on a cooperative project involving The University of Texas and the San Antonio Independent School District. This project was designed to improve the teaching of earth science. Two geologists, one science educator, and four eighth grade science teachers served in an advisory capacity one summer to develop curriculum materials. Inservice workshops, held at the end of the school day, were conducted on a biweekly basis, with 51 teachers participating. The teachers carried out 30 student experiments. The feedback which they provided was used to revise the materials.

Another program, also financed by a Cooperative College-School Program grant, was aimed at modifying biology curricula to be used with a multiracial student population (5). This project involved a semimonthly inservice teacher training program. Behringer conducted a study, in conjunction with this project, to determine if the program of curriculum differentiation and teacher training was effective in providing for the need of different levels of student ability. Effectiveness was measured in terms of student achievement. Gains in learning were significant for all groups.

These inservice programs took place during the academic year. The teachers participating in them were involved in this work in addition to their usual teaching duties and activities. A different kind of NSF-funded Cooperative College-School Science Program was that investigated by McCormick (49). The purpose of this study was to develop an innovative inservice program which would provide high school biology teachers with (1) an increased understanding of the processes of science and (2) the necessary skills for including these processes in their teaching.

A ten week program was developed. In the first phase, 31 high school biology teachers investigated ecology, concentrating on principles and concepts. During the second phase, each of the participating teachers supervised a similar ecological investigation by one of his students. Both teachers and students submitted their findings in the format of a scientific paper.

The effectiveness of this experimental program was assessed by onsite visits in the fall and a survey-questionnaire in the spring. Twenty-two teachers responded to the questionnaire. Eighteen teachers were using the outdoor laboratory in their teaching. Fourteen outdoor laboratories were in use for the first time. Fifteen teachers were using the outdoor laboratory for entire classes and four teachers were using the outdoor laboratory for general science classes. Twice as many students were involved in independent study as during the previous year. It would appear that the experimental program had resulted in modifications, in teaching by the participants, in the direction desired by the developers of the inservice program.

Traveling Science Demonstration Lecture Program (National Science Foundation)

Another approach to the problem of inservice education for classroom teachers is the traveling science demonstration lecture program. A study reported by Bogen (13, 14) described a program, originated at The University of Oregon, involving classroom teachers trained as demonstrators.

These demonstrators were provided with equipment and station wagons in which to travel. They spent the academic year visiting schools from which the project had received requests for their services. The demonstrators spent approximately one week at each school visited, giving lecture-demonstrations to science classes as well as to special student, teacher, or civic groups. They also discussed science education problems with teachers and administrators.

The traveling science lecture demonstration program was evaluated through questionnaires sent to the 415 teachers visited and through another questionnaire to the 11 individuals who had served as demonstrators. The classroom teachers indicated they thought they had increased their teaching skills and techniques and had gained useful information. The reactions of the demonstrators were mixed but the favorable responses outweighed the unfavorable. The consensus was that the program was better than the usual summer institute for increasing classroom effectiveness.

Research Participation Programs

Several reports were found in which the approach to inservice education was a summer research program for science teachers [Bruce and Johnson (17), Schaefer (73), Sarner (71)]. Schaefer described a nine week summer program in which teachers were able to work in laboratories. He felt that such a program was valuable in that teachers with a background in research could aid their students in finding information. He also thought that teachers with research experiences would be more effective in helping their students develop confidence that they too were capable of doing research.

Bruce and Johnson (17) reported on the teacher research program at Cornell. They felt that such a program provided teachers with the opportunity to change from being individuals who know about science to people who know what science is about. The participants in this research-oriented program carried on scientific research in their schools, involving a few of their science-oriented students. Teachers and students worked under the guidance of a research scientist who served as a consultant. The majority of the research proposals were developed by the scientists and the projects were teacher oriented rather than student oriented. Evaluation of the program had not been completed at the time of publication of the article. The authors did, however, indicate that the subjective judgment of those concerned with the evaluation was that, as a result of their participation, both teachers and students increased in their understanding of science as a process of inquiry.

Sarner (71) reported an attempt to retrain inservice teachers to use a "critical thinking, problem solving" approach in their science teaching. These individuals worked as part of a research team on an ongoing research problem. The six week research was preceded by a week of orientation and followed by a week devoted to discussing methods of using critical thinking and problem solving in their science classes.

Summer Institutes (National Science Foundation)

The majority of the summer programs reported in the literature involved attendance at summer institutes for six to nine weeks. Some programs were designed to provide teachers with opportunities to investigate more than one science. In other programs the approach was one in which the teacher enrolled in several courses all of which were related to a particular science. For example, Mertens and Nisbet (51) described a graduate credit course in cytology which was offered as a part of a unified institute for high school biology teachers. In addition to this course, the teachers took a course in biochemistry and a third in BSCS biology.

Although most of the institute programs reported were designed for teachers of a particular science, one article contained a report of institutes for junior high school teachers of general science (78). Indiana State College personnel designed these institutes using the rationale that general science teachers usually have backgrounds in biology and chemistry but lack preparation in physics, astronomy, and geology.

For the summer institutes, the participants were divided into two groups on the basis of their scores in a biology examination. Those with high scores took astronomy. Suttle summarized the report of the activities with the statement that the participants felt the institutes were worthwhile and that many went on to do more graduate work.

Local Programs

The programs described in this paper have been of the variety that have been planned by sources removed from the local situation. It is assumed that many local programs which develop out of action-research activities within a particular school or school system never become published other than in the form of some curriculum manual or teacher's guide and therefore are not available for a more general public to analyze and review.

It may also be true that local programs receive little attention due to lack of funding. However, some local activities have been initiated under Title III.

Title III programs are of two types. Those under PL89-10 Elementary and Secondary Education Act of 1965 are sometimes referred to by the acronym PACE, Projects to Advance Creativity in Education. This provides a five-year program to stimulate innovative and exemplary programs and to support supplementary educational centers and services. Three basic functions are possible: (1) to improve education by enabling a community to provide services not now available to children who live there, (2) to raise the quality of educational services already offered, (3) to stimulate and assist in the development and establishment of exemplary and secondary school educational programs to serve as models for regular school programs. (67)

Approximately 30 proposals for funding under the PACE Program of Title III were read during the process of compiling information for this paper. At least 15 of these were investigated through telephone calls to the individuals listed as contacts for further information. Several complied with a request for further information. In most instances the programs were still in the developmental stage. Such programs are not included in this report because they are subject to further changes and also because the evaluative component of most of the programs had not been formulated in any detail.

A second type of program is that of PL85-864, National Defense Education Act of 1958 (Revised). Title III, here, provides financial assistance for strengthening instruction in critical subjects in the elementary and secondary schools. Funds may be used to pay for instructional equipment and materials, minor remodeling, and for state supervision and administration of the programs. (67)

The Bethlehem Area School District in Pennsylvania (8) published a report of a Title III funded workshop for teachers and students in nuclear science. Fifty people participated. The teachers involved gained subject matter content, practice in manipulative skills in the use of the various monitoring instruments, and experience in recording data and plotting graphs of collected data. It was hoped that participation in the workshop would change the teachers' beliefs that the cost of the equipment would prohibit student use and that the teachers would incorporate "nuclear experiences" into their existing chemistry, physics and biology courses.

Another result of work at the local level is the program of the Pacific Science Center in Seattle (62). The Center, in conjunction with the Puget Sound Arts and Sciences Program, conducts a variety of inservice training programs and workshops. It also contains a model science classroom-laboratory which is used for some inservice education activities. Although the emphasis is on workshops for the elementary school teacher, there are programs for secondary school personnel. A number of workshops provide not only the necessary background and training in new science programs but also materials which the teachers may take with them to use in their classrooms.

Junior and senior high school teachers have participated in workshops at the Center which were designed to acquaint them with the curriculum and materials involved in the Earth Sciences Curriculum Project and the Biological Sciences Curriculum Study as well as with Introductory Physical Science. In addition, secondary school science teachers were offered the opportunity to participate in a workshop on current developments in the space program and recent discoveries in astronomy.

The Science and Mathematics Improvement Project (74) that serves teachers in a five county area in Pennsylvania has been in operation for two years. During this time, college professors and high school teachers have worked together to develop a variety of inservice activities. Individuals have been involved in writing materials for classroom use, preparing kits of valley rock-types, producing and distributing a set of nine SMIP filmstrips to each high school in the region, participating in inservice programs on single school levels as well as county levels, and planning for three different programs for the 1969-70 school year. Curriculum guides in each of the major science disciplines (biology, chemistry, physics) have been developed. SMIP materials include a course called environmental science. Predicated on the judgment that typical earth and space science courses try to cover too much material, the environmental science course emphasizes looking, describing, and relating. It is composed of five major units. Teachers participating in the inservice activities involved with this course receive free credit at Wilkes College, Wilkes-Barre, Pennsylvania. There are college credit courses in the other science disciplines and in mathematics also.

The Project publishes the SMIP Newsletter. These newsletters contain information regarding materials available to teachers, as well as announcements of workshops and courses, and short articles on mathematics and science education.

Personal communication from the Associate Director of the Project provided the information that over 1500 pieces of curriculum material have been requested by area teachers. When this information was provided, in late June of 1969, 97 teachers had indicated an interest in taking the SMIP fall courses, 88 had asked for applications to the summer workshop, and five schools were planning to give their teachers released time to work with the SMIP staff on curriculum development. These facts appear to provide evidence that this project is providing necessary, useful inservice activities for teachers in the area it serves.

The Corpus Christi, Texas, Independent School District personnel worked with individuals from parochial schools, a member of the National Audubon Society, and officials from the Wilder Wildlife Foundation (21). They organized a workshop in conservation education in which teachers were able to work in the laboratory as well as in the field. The information sent the ERIC Center did not contain any description regarding evaluative activities, if any, involved in the program.

Inservice education in the Corpus Christi Schools is also accomplished through a Life Science Education Center. Personnel at the Center make arrangements with local universities for courses that fit the needs of the various school faculties within the system. The Center also makes it possible for teachers to contact and work with community resource persons such as commercial fishermen, beekeepers, and members of the humane society.

Bedrosian and Pincus (4) reported on three institutes (chemistry, mathematics, and physics) sponsored by the Newark College of Engineering Research Foundation. The material was geared for the level of college sophomores. The authors concluded that the 30 week institute did help up-date the teacher participants. More success was achieved by those teachers with adequate grounding in the fundamentals of the subject prior to enrolling in the institute than by those with minimal backgrounds.

Organization-Sponsored Inservice Programs

A science program entitled "Interaction of Matter and Energy" has been developed as a Rand McNally Curriculum Project (64). This program is considered to be a new approach to teaching physical science at the ninth grade or junior high school level. Based on an inquiry approach, it has been designed to provide a strong physical science background for students who are terminating their science study in the ninth grade as well as for those who plan to enroll in science in senior high school. Teachers who plan to use the IME Program are invited to attend "briefing sessions." During these two day sessions teachers are asked to assume the role of students as they work through the laboratory investigations and participate in the follow-up discussions. In this simulated classroom situation the writing team for the IME Program or teachers who have taught the course explain the rationale, content, technique and goals of the program.

The Educational Research Council of America is another organization that has developed secondary school science materials (25). It provides services to school systems wishing to use the ERC science programs. These activities range from half-or full-day orientation sessions to workshops lasting four or five days. Teachers who are using the materials for the first time may also attend "briefing sessions" held on Saturday mornings or after school. During these sessions a new or improved technique, a piece of apparatus, or an experiment is explained and demonstrated. In addition, teachers receive information of the how-to-do-it variety via memoranda and newsletters. Feedback seminars are also held, involving teachers who are using the ERC programs and the staff members who have developed and written the materials. The ERC personnel feel that this fluid and flexible approach to inservice education is more useful than that of providing help via an established course dealing with only predictable difficulties.

Statewide Inservice Activities

In many instances workshop participants may travel to a field studies center or to some location other than that of the school in which they teach. A different approach to the problem of inservice education was reported in a study by Kerns (43). This program was an attempt to upgrade the quality of instruction in junior high school science in Alabama through the use of the statewide educational television network. The program was initiated and developed by personnel in the School of Education at Auburn University.

The program was designed to serve five major functions: (1) to be a demonstration program for the teachers, (2) to show the teacher how his needs could be met in his own classroom, (3) to provide practical suggestions that the teacher could follow up, (4) to suggest ways by which the teacher himself could enrich his classroom work, and (5) to teach the teacher while in his classroom. Each of the in-school telecasts was designed to instruct students while also providing inservice education for the teachers. There were additional after-school telecasts for teachers only. A field conference service was established to serve as a liaison between the classroom teachers and the project.

The program was designed for teachers with little teaching experience and minimum preparation in the academic areas. The reactions of the participating teachers varied relative to their academic backgrounds and teaching experience. Kerns reported that the teachers who were relatively highly qualified in terms of formal preparation and with more experience in science laboratory work considered the time spent viewing less valuable than other teacher-selected and directed activities, indicating that the program had been produced at the intended level of sophistication. The project as a whole was evaluated in a separate study by Steele (77) which will be reviewed in a later section of this paper.

Inservice Institutes

Usually most inservice institute programs concentrate upon helping classroom teachers improve their knowledge of one or more of the sciences. A different approach to inservice education for science teachers was reported by Lavach (45). He developed, presented, and evaluated an inservice course in the historical development of physical science concepts. The course involved both lecture-demonstration and laboratory instruction. The laboratory portion consisted of replicating experiments discussed during the lecture or of conducting parallel experiments which provided experimental support for the concepts presented.

Lavach found that the 11 teachers enrolled in the program made statistically significant gains in understanding the historical development of science with respect to the topics presented in the course. They also made statistically significant gains in understanding the methods, aims and overall nature of science. The participants expressed sufficient confidence in their comprehension to include in their own teaching at least one unit from the five presented to them.

No attempt was made, as a part of this study, to follow up the participants and to investigate whether they really were using historical materials in their junior and senior high school science classes. Nor was any attempt made to determine what changes, if any, were made in the understanding of the students of these teachers.

Overview of Program Descriptions, Reports, Studies

Many of the reports of programs were limited to program descriptions. Few articles other than doctoral studies contained information relative to what procedures had been undertaken to evaluate the effectiveness of the inservice activities. It would appear that many individuals or school systems developing inservice programs or activities rely on intuitive feelings about a particular program's effectiveness. In a study such as that done by Behringer (5), effectiveness was measured, at least in part, by gains in student learning. In other instances, long term studies would need to be done in order to determine whether or not, or to what degree, an inservice program had been influential in producing a change in the students through changes in the teacher's content background or his approach to content.

EVALUATIVE STUDIES

There were a number of studies published in which the major emphasis was upon evaluation. The majority of these centered around analyses of one or a series of National Science Foundation Institutes given at a particular college or university [Jenkins (41); Heideman (37); Welch & Walberg (82), (83); Educational Testing Consultants (26), (27), (28), (29); Ward (81); Selser (75); Steele (77); Wittwer (85); Milliken (53); Horner (39); Martinen (48); Gruber (32); Brekke (16); Berger & Berger (6).]

Beginning in the 1950's, inservice, summer, and academic year institutes for teachers were developed and promoted under the auspices of the National Science Foundation. These institutes were designed to achieve the following goals: (1) to up-date the subject matter preparation of teachers who were adequately prepared in science or mathematics when they entered the teaching profession, (2) to provide remedial training for teachers whose undergraduate preparation was inadequate, (3) to equip teachers with specific background to teach newer curricular materials, (4) to enable teachers to study a subject in greater depth and to meet new, higher standards which might or might not entail an advanced degree, and (5) to provide advanced specialized training for individuals holding or desiring to hold positions of leadership in science education, such as science supervisors (56).

The earliest NSF institutes were of the summer variety, lasting for six to eight weeks and providing teachers with opportunities to update their subject matter background. Those institutes in operation in 1953 were for college teachers. They were followed, in the summer of 1954, by similar institutes for secondary school teachers. Academic Year Institutes, which began in 1956-57, were increased in 1959 to include some college teachers as well as secondary school teachers. The Inservice Institute Program, begun in 1957, was similarly expanded in 1961. Summer Institutes and Inservice Institutes for elementary personnel were begun in 1959 (56).

In addition to the doctoral dissertations in which the investigator evaluated the effectiveness of a particular institute or series of institutes in terms of changes in the participants, the programs have also been evaluated by (1) analytical studies by staff members, based on reports from the institute directors, (2) statistical analyses of data accumulated from participant application records, (3) reports of visits by staff and consultants to institutes in progress, (4) group discussions at annual conferences of institute directors, (5) studies of effectiveness of particular institutes by their staff or in graduate student theses (as mentioned earlier), and (6) by contract studies by independent research firms.

It was not possible to obtain an example of each type of evaluative study to include in the materials reviewed for this report.

Evaluations of Academic Year Institutes

One study reviewed for this report was concerned with the investigation of unique features of Academic Year Institute science courses, their orientation, academic level, and successes (81). Institutions at which special courses had been offered for two or more years were contacted. Questionnaires and personal interviews were used to obtain the data. Ward found five features to be common to the special science courses offered as a part of the institute: (1) a review of basic fundamentals of science, designed to bring the participants' knowledge up to date, (2) an emphasis on materials related to high school instruction, (3) graduate credit was generally offered, (4) the material was less rigorously treated than in the usual academic science courses, and (5) the institute participants rated these courses as being of more value to them than the regular college courses in which they were enrolled.

Although the rigor of the content, such as the mathematical requirements for the courses, was less than that of the regular graduate courses, the scope of content and emphasis on fundamentals compared favorably with the regular courses. Ward suggested that since the special science courses apparently were needed by the teacher-participants, these courses might be used as possible models in the restructuring of undergraduate programs for prospective science teachers.

Heideman (37) conducted a pilot study involving 123 teachers who had been participants in the Academic Year Institutes at the University of Wisconsin from 1956-1959 to determine the effects of participation one to three years after the institute program had been completed. He was also interested in determining whether identifiable personality traits and intellectual characteristics of program participants existed, if AYI participation had affected occupational mobility, if strengths and weaknesses of undergraduate programs could be discovered through an analysis of graduate programs, and if the program at Wisconsin accomplished the objectives of upgrading the teachers and removing their academic deficiencies.

After Heideman analyzed the replies to his semi-structured questionnaire and personal interviews, he concluded that the programs had been beneficial. The participants appeared to have increased in their ability to generate new ideas, to create new teaching concepts and in their desire to try new teaching methods. They had also increased the effectiveness. This might imply the existence of a "teaching personality" which is determined by home, school, and community influences and which greatly influences teaching effectiveness. Apparently, if participation in an inservice program such as an Academic Year Institute can enhance or increase teaching effectiveness, the experience also changes this "teaching personality," if it exists.

Another evaluative study of NSF academic year institutes was done by Jenkins (41) and involved the first five institutes at The University of Utah. In addition to sending a questionnaire to AYI participants, Jenkins studied information contained in application forms and asked the staff members to react to the participants and to the program. As in the other studies cited, Jenkins found that the respondents to his questionnaire were of the opinion that they had improved their teaching or some aspects of it and that they had increased their knowledge of subject matter.

The majority of the respondents also indicated their belief that their prestige, attitudes, leadership and professional growth had improved. The majority of the staff members contacted believed that the program was satisfactory and was achieving its goals. One goal that apparently was not achieved was that of having the AYI participants influence more of their students to choose careers in science or mathematics.

Horner (39) concentrated on only one Academic Year Institute. His study was conducted to determine the extent to which the AYI at Syracuse University in 1960-61 had met four major objectives: (1) improving the subject matter comprehension of the participants, (2) improving their teaching, (3) strengthening their capacity to motivate their students to consider careers in science, and (4) increasing the motivation of the participants for continued growth as science teachers.

He involved two control groups as well as an experimental group in his study. The experimental group consisted of 23 AYI participants who returned to secondary school teaching following the program. The first control group was composed of 24 science teachers selected as alternates for the AYI at Syracuse. The second control group consisted of 13 teachers working in the same schools as the AYI participants in the year following the program. Teachers in both control groups had attended summer institutes.

Horner translated objectives two, three, and four into 16 specific objectives for science teaching. Sample objectives were (1) increased amount of time spent in the laboratory, (2) use of experiments not previously employed by the teacher, (3) change from single text or limited sources to multiple text or extensive sources, (4) increased use of problem-solving approach in the laboratory, (5) increased participation in extracurricular activities in science, (6) increased personal subscriptions to scientific and professional science education periodicals, (7) increased membership in scientific and science education organizations, etc.

Data were gathered from personal interviews, a questionnaire, and analyses of the participants' Institute and pre-Institute academic records. The two control groups supplied information via a questionnaire.

Horner found that the participants and their supervisors felt that the AYI experiences had enabled the teachers to make considerable progress toward the 16 objectives. Both depth and breadth of subject matter competence were achieved. However, an analysis of the changes in the 31 teaching and professional activities into which the 16 objectives had been subdivided showed almost no significant differences between the performance of the Institute group and the respective control groups. Only two of the 62 comparisons showed statistically significant differences at the .05 level. The Institute group exhibited a significant increase in science and professional science education organization membership when compared with control group one. The Institute participants also displayed significantly more progress in the utilization of "open-ended" or "inductive" type laboratory experiments than did the members of control group two.

When the members of the experimental group were asked for subjective judgments, they considered participation in the program to have had a decidedly beneficial effect. Their supervisors rated the effect slightly higher than did the teachers. When the responses to the items were grouped under appropriate major objectives (listed earlier), the greatest progress was indicated toward objectives two and four, improving teaching and increasing motivation for continued professional growth.

As in other evaluative studies of the effects of institute attendance, Horner found that it appeared to enhance the participants' self-confidence as science teachers. It also appeared to influence them to place more emphasis on current happenings in science in their teaching as well as promoting increased membership in scientific and science education organizations.

Brekke (16) conducted a follow-up study on individuals who had participated in institute programs at the University of North Dakota from 1957-58 through 1961-62. He was interested in determining the effectiveness of the programs in meeting eight stated goals. These goals covered objectives promoted by the NSF projects such as strengthening content background, supplying up-to-date information, increasing the teachers' capacities to motivate their students to pursue careers in science and/or mathematics.

He sent questionnaires to institute participants and their principals. The teachers were asked to complete a questionnaire in the fall and again in the spring to determine if they had changed their evaluations. They generally increased their evaluation of the institute's effectiveness between fall and spring administrations of the questionnaire. In the spring, they were less concerned with teaching techniques and more pleased with their growth in content knowledge.

Brekke also found that the participants of the Academic Year Institutes were more critical of the effectiveness of their programs than were those who had participated only in summer programs. The majority of the respondents felt that institute attendance had been beneficial and had resulted in increased enthusiasm for science and mathematics as well as in a desire to gain a graduate degree through further study.

The high school principals identified the institute participants as having increased subject matter competency, teaching effectiveness, and ability to motivate. They had also made efforts to improve facilities for science teaching in their schools. Both teachers and principals agreed that the least changes were made in method.

One major criticism resulting from the evaluation of the first year of the Academic Year Institute program at the University of Colorado was that the participants had not acquired the attitudes and information relevant to teaching science as a way of thinking as opposed to teaching science as a body of knowledge. Gruber (32) was stimulated by this criticism to investigate its applicability to the entire AYI program in the academic year of 1958-59.

During that period there were 15 AYI programs in the United States. Gruber was unsuccessful in obtaining information from the participants from all 15 programs but he did receive responses from 9 different institutes of varying geographic locations and academic programs. He obtained information about the background of each of the teachers participating in his study via a questionnaire completed immediately after the major task involved in the study.

Each of Gruber's subjects was asked to prepare an outline of a 20-30 minute talk appropriate for delivery to high school seniors. The topic chosen was to be one quite familiar to the teachers. These outlines were rated to determine the extent to which the teachers were concerned with presenting science as a way of thought as compared to presenting science as an established body of knowledge. Forty-three of the 202 outlines were rated by a second judge, to test the reliability of Gruber's rating system. (No information was contained in the article as to the background or position of the individuals chosen to do the rating.)

Gruber used seven variables in his study. The criterion variable was teaching science as thought. He found that the most important program characteristic in the case of those individuals receiving a rating of "strong" on this variable was the proportion of time the particular institute allotted to methods of teaching requiring the active participation of the individual in the learning process. Programs ranking high in the use of seminar and laboratory work and high in the freedom with which the participants were allowed to choose their own courses also ranked high on the criterion variable. Programs stressing lectures, tests and prescribed courses ranked low on the criterion variable.

Gruber concluded that much previous course work in science and mathematics prior to enrolling in the institute was neither a necessary nor a sufficient condition for strong performance on the criterion variable. Apparently an unfavorable AYI program could overcome a favorable educational background and a favorable program could produce good results in individuals whose previous training was less than adequate.

Gruber also concluded that (1) high school teachers generally approach science teaching as a matter of conveying science as established facts and doctrines, (2) training programs stressing passive-receptive teaching methods do little to alter this approach, and (3) training programs stressing active participation by the teacher-participants may lead to an approach to science teaching in which science is treated as a way of thought.

It would appear that the goal of teaching scientific ways of thinking through the teaching of science is still difficult to translate into some workable methodological form. However, producing students who understand science as a method of thought and inquiry is a more desirable educational achievement than producing individuals who have accumulated a storehouse of facts and information which quickly become out-dated. It would also appear that the designers of institute programs can be helped to restructure their teaching.

Evaluations of Summer Institute Programs

Some degree of attainment of the objective of having teachers increase their understanding of scientists and science was reported by Welch and Walberg (82), (83). They evaluated summer institute programs for physics teachers. These investigators decided that few experimental studies had been done relevant to whether or not teachers have been "affected" in the manner specified by stated objectives of the institute programs, i.e. does the available evidence indicate that attendance at a summer institute results in increased "subject-matter competence" on the part of the participating teacher?

Welch and Walberg measured gains in (1) knowledge of the subject and (2) general understanding of scientific methods and processes. They included four institutes in their analyses and concluded that all four did achieve the objective of increasing subject matter competency. The instrument used to assess subject matter competency was the Test on Selected Topics in Physics (TSTP).

Several institutes also achieved goals of increased knowledge of scientific processes and understanding of scientists and science, as measured by the Test on Understanding Science (TOUS) and the Welch Science Process Inventory (SPI).

The authors suggest that a study to identify the relationship of objectives and teacher activities in various institutes to the differential gains in the general understanding of science might be useful. It might be possible, through such an investigation, to establish what goals and activities lead to what outcomes.

Martinen (48) studied a series of Summer Institutes held at The University of Idaho from 1957-1964. He was interested in studying the effects of summer institute participation on teachers' educational stature, professional stature, occupational mobility, and ability to initiate curriculum change within their schools. He found that those individuals with the most extensive institute training were the most apt to alter curricula. Those teachers with three summer's training and an advanced degree continued to initiate change at a rate greatly exceeding that of the recipients of only one summer's training. This difference was not statistically significant, however.

He also found that new units which had been added to the high school courses of study could, in most instances, be traced to the content of the curriculum offered by the NSF Institutes. When new courses were added in the secondary schools, the majority required teachers who were subject-matter specialists.

Ninety-seven percent of the individuals replying to Martinen's questionnaire indicated they had increased their subject matter competency as a result of their institute attendance. Very few, however, felt that this attendance had any influence on the positions they held although they did acknowledge that salary and certification benefits had resulted.

Milliken (53) conducted an investigation involving both summer and inservice NSF institutes offered at Kansas State College, 1959-63. He used a questionnaire to attempt to gather information regarding the significance of these institutes as evaluated by the teachers who had participated in them. He emphasized the aspects of (1) renewing knowledge of fundamentals in science and/or mathematics, (2) acquiring knowledge of recent developments and advances in science and mathematics, and (3) becoming familiar with new teaching methodology.

Milliken found that nearly all the respondents in his sample were able to renew their knowledge of fundamentals and become acquainted with recent developments and advances in mathematics and science. Institute attendance did influence respondents to make "some" changes in their teaching methods and comparable course content changes. Mathematics appeared to be the only major area in which the majority had studied the newer curricula in their institute program.

Milliken felt that it was possible that certain institute co-curricular activities contributed more concomitant information on improved methodology than did the structured curricular activities. These "co-curricular activities" appear to have been informal discussions that the institute participants held outside of class.

Evaluation of Inservice Programs

In addition to the study just cited, one other investigator was concerned with the evaluation of an NSF inservice institute. Selser (75) investigated an inservice institute designed for science and mathematics teachers in a county in Florida. In addition to investigating the effect of the institute on content knowledge and conceptual ability of teachers, he wished to determine the effect, if any, on their pupils. He set up experimental and control groups, using stratified random sampling techniques for classes involved in the study.

The teachers were given the STEP (Sequential Test on Educational Progress) in science and the TOUS (Test on Understanding Science) tests. The pupils received the STEP test in science as well as the Iowa Test of Educational Development in science. Selser found that the science teachers who participated in the institute gained in their understanding of the nature of science and in their ability to identify and define scientific problems. The pupils of the teachers who had participated in the inservice program made significantly higher scores, at all grade levels (7, 8 and 9), on the STEP test of their ability to identify and define scientific problems. They also exceeded the scores of the pupils in the control population on the ITED test of ability to understand scientific literature, but the difference was not statistically significant at the .05 level of confidence.

Evaluation of a Research Participation Institute Program

Wittwer (85) designed a study to evaluate the effects of participation in the NSF Research Participation Program for secondary school science teachers at The University of Wisconsin. Individuals who had been in this program at some time between 1959 and 1966 were contacted for their opinions concerning the influence of this experience on employment status, subsequent academic program and professional image. Wittwer also wished to determine the teachers' success of establishing research at the high school level. The teacher-participants were also given a specially designed Science Process Inventory in an attempt to determine their understanding of the methods or processes of science. Their scores were compared with those of a comparable group of teachers who had not participated in the research program.

The professors who supervised the research activities during these programs were questioned regarding their opinions of the teacher-participants' understanding of the real nature of research and the significance of their contributions to the research discipline.

Wittwer found that participation in the research program was considered, by the teachers, to be instrumental in changes in employment for some, in a return to graduate school, in the joining of professional societies, in the reading of research journals, and in an increase in prestige among their colleagues, administrators and students. In addition, nearly all the respondents indicated increased competence, effectiveness, and self-confidence as teachers.

Approximately 60 percent of the teachers also participated in the Academic Year Extension phase of the program. This was an attempt to establish a research program in their high schools. However, more than 80 percent reported that no adjustment had been made in their teaching schedules of extracurricular assignments in order to provide them time to continue research.

The supervising professors were of the opinion that more than 90 percent of the participants had gained an understanding of the real nature of research and that nearly one-half of them had made a significant contribution to the research discipline. They also felt that almost three-fourths of the participants had made a significant contribution to the output of the professors' laboratories.

The teachers who had participated in the research program scored significantly higher on the Science Process Inventory than did a comparable group without research experience. On the basis of this and other data he collected, Wittwer concluded that the research experience program was a worthwhile addition to the education of secondary school science teachers, if the objectives of the program are accepted as valid. These objectives were (1) to provide activities and responsibilities meaningful in terms of research in science or mathematics, (2) to enable the teacher-participants to generate tangible research results, and (3) to develop in these individuals understanding of the methods or processes of science.

Evaluation by Independent Research Firms

The investigation by Berger and Berger (6) cited at the beginning of the "evaluation" section of this paper will be discussed in the "research" section that follows. This study and a series of studies done by Educational Testing Consultants for the Academic Year Institute programs at The Ohio State University (26-29) were the only reports identified as having been done by independent research firms.

The investigations conducted for The Ohio State programs involved the participants during the time they were enrolled in the program as well as follow-up studies a year later. The spouses of the participants were also questioned as were the school administrators who hired the participants. The investigators found that the teachers tended to rate the benefits of the program somewhat lower after a year had elapsed than they had originally. No attempts appeared to have been made to determine the cause of this change in evaluation. The principals were well pleased with the program as it was reflected in the teaching behaviors of the participants. Many principals had given these teachers increased professional responsibility as well as limited financial rewards.

Other Evaluation Studies

Steele (77) based his doctoral dissertation on the evaluation of a statewide inservice television project conducted in Alabama. Evaluation was conducted by (1) field conference workers who cooperated with the other members of the research team, (2) preservice science teachers, and (3) teachers, teaching principals, and the general science students involved in the project. Several different techniques and instruments were used, including (1) descriptive analysis, (2) field observations, (3) interviews, (4) questionnaires, and (5) rating scales.

Steele found that (1) 70 percent of the teachers involved felt that they had become better overall teachers of general science, (2) 58 percent felt their general relations with their science students had improved, (3) 45 percent felt that the television project had resulted in changes in their methods of teaching, and (4) 39 percent felt that the experience had resulted in changes in their philosophies of teaching.

The project was limited by the small number of personnel involved and was also hampered by lack of television sets, poor reception of the television picture, and difficulties in scheduling the viewing times.

Steele concluded that sufficient knowledge had resulted from this study to be used in developing and establishing more productive methods of telecast inservice activities. He suggested that a need might exist for the establishment of an office of television services which could function under the general direction of the Office of Field Services of the School of Education so that the cooperative relationship between the college and the public schools could be maintained.

Other types of evaluation administered to inservice programs have not been so elaborate as those in Steele's study. A great deal of evaluation in the nationally-funded course content improvement projects appears to be of the informal feedback type. Much of the information included here was gleaned from newsletters published by the various projects or from individuals intimately connected with the various projects who were personally contacted and asked to supply information relative to the evaluative activities being conducted in the inservice component of these programs.

All of the individuals contacted agreed to cooperate and did send information (63, 79). This information consisted largely of copies of comments made by participants of workshops and other activities. Comments ranged from "Great--invite me back again next summer!" to "Chairs in the lecture room too hard." In some instances specific criticism and suggestions for improvement were made relative to lecturers, topics and activities. Little information was received concerning any evaluative instruments that might have been used in a pre-and post-test design or even as a post-test only for the various activities.

Information culled from reading the newsletters issued by the curriculum projects was of a general nature, also. Issue #7 of the Earth Science Curriculum Project Newsletter contained an article on the ESCP program of objective testing. It was stated, in April 1965, that students would be given tests to determine their academic aptitude as well as tests to measure their background of scientific information. A special test, the Test of Scientific Knowledge (TOSK), was designed by the ESCP staff and the Psychological Corporation. The first part of the test, 60 items, is designed to measure specific information from the physical and natural sciences and covers terms, definitions, relationships, etc. The second part, 50 items, is designed to measure the student's grasp of scientific principles, methods and procedures.

The testing program was to include teachers and students involved with ESCP and also a control group of 21 teachers and their ninth grade students. The analysis of test results was scheduled to be published in the summer of 1965. However, no subsequent analysis was located.

Two other curriculum project groups, the Biological Sciences Curriculum Study (9) and the Chemical Education Materials Study (19) publish newsletters. These newsletters, like those of the ESCP project, cover items of general interest to teachers in the specific sciences and contain announcements of institutes being offered that relate to the particular project. The various project staffs send out questionnaires from time to time and report on the results of these in the newsletters. These questionnaires cover such topics as teacher preparation, enrollment surveys for a particular subject, and reactions to the project materials.

Harvard Project Physics (35, 36) also publishes a newsletter and a teacher's newsbrief. Rand McNally publishes a newsletter related to the course entitled Interaction of Matter and Energy. These publications usually are issued on a quarterly basis and provide their readers with information about ongoing activities of the project group as well as serving as a forum for expressing opinions and issues in science teaching.

In addition, the Harvard Project Physics Course staff has issued an interim report relative to the evaluation component of the program (1). This component involves several types of activities: (1) feedback from teachers and students which is used for course improvement while the material is being developed, (2) evaluation of what changes have taken place in students for the information of potential users of the course, and (3) basic research in education.

The feedback began during the school year of 1964-65. It consisted of such things as analysis of items on the achievement tests designed for the course, student ratings of the effectiveness of communication and of the difficulty of the chapters and experiments, analysis of the density of the new concepts, and extended discussion with teachers at regional conferences.

User information and basic research activities appeared to be carried out in parallel form. While the course improvement phase of the project was essentially completed in 1967, the other two components continued to operate. A pilot study took place in 1966-67 and a full scale experimental study was conducted in 1967-68. The purpose of the investigation was to describe what happens to different kinds of students in different kinds of classes.

Teachers whose students were involved in the study were chosen by random selection from a list of high school physics teachers compiled by the National Science Teachers Association. In the group agreeing to participate in the study, teachers were assigned to experimental and control groups by use of a random number table. The study involved pre-and post-test batteries as well as a group of tests given only once, at mid-year. Additional data were collected at the end of the year.

This research involved the use of standardized tests, such as the Test on Understanding Science, the Henmon-Nelson IQ Test, the Allport-Vernon-Lindzey Study of Values, and a Biographical Inventory. Several test instruments were developed for the study. A student questionnaire and a semantic differential test designed to assess student attitudes serve as examples.

At the time the interim report was issued, in February 1969, the data were still being analyzed. However, two documents are scheduled for publication within a year. One will be a relatively technical report of the evaluation program. The other will be a more popularized summary of the results.

From the analyses of available results of the three tests: TOUS, the Physics Achievement Test (PAT), and the Science Process Inventory (SPI), Ahlgren has concluded that: ". . .on the average, Project Physics students scored higher on these three tests than they would have had they been in the control group classes."

In addition to considering student achievement, the study was concerned with interest in physics. The several independent measures of interest all show similar results: a decrease in interest. Nevertheless, even at the end of the year interest in physics tended to be high. In addition, several studies in other subject areas such as foreign language and astronomy have shown a similar loss in interest by the students involved.

Some Summarizing Remarks about Evaluation of Inservice Programs

If one agrees with the assumption that the true test of the effectiveness of an inservice program is in the changes made in the teachers which then become evident in their students, it would seem that more investigation needs to be done in this area of evaluation of both teachers and students. Although some work on evaluation is being done, the problem of determining the effectiveness of inservice activities still remains. Based on available information, several inferences can be made: (1) a formally designed evaluative component has not yet been built into all inservice programs, regardless of whether the inservice activities exist by themselves or in conjunction with a curriculum project, (2) the evaluative part is in the process of being established and the results will be available at a later date, or (3) evaluation exists but the information gathered is not available for public scrutiny for reason or reasons unknown.

It would seem that if a curriculum program is worth time and money to design and implement, it is also worth careful evaluation of effectiveness and particularly of the effectiveness of its inservice activities. It is unlikely that the most carefully planned and well-written curriculum project can ever be fully effective if the classroom teachers using the equipment and materials do not understand and subscribe to the philosophy underlying the program. Is having a grasp of the content involved sufficient to guarantee that the course will result in more than a change of textbooks and the schedule of assigned topics? It seems imperative that attention be given to the inservice and evaluation components of these various curriculum projects as well as to designing laboratory activities and textbooks. This same admonition holds true for locally initiated and developed inservice programs. More than the intuitive hunches of the people involved is needed to constitute an adequate program of evaluation.

The studies and reports cited in the evaluation section of this paper serve as examples of what has been done by different individuals and groups. The Harvard Project Physics Interim Evaluation Report and future publications can serve as examples of what can be done to determine the effectiveness of curriculum change and inservice work by teachers as evidenced by changes in the student population. Such studies do not have to be as ambitious an educational research project as the one just cited in order to determine this information. The variety of available material is such that it is difficult to generalize from it. The readers of this report are therefore welcome to draw their own inferences or to pursue a more detailed investigation by referring to the original sources listed in the bibliography.

RESEARCH STUDIES

Another group of studies[Berger and Berger (6), Roye (70), Menesini (50), Irby (40), Blankenship (10), Dzara (22), Sarner and Edmund (72), Bradberry (15), Jorgensen (42), Nixon (57) Shrader (76), Barfield (3), Voth, Leonard and Denney (80), Rothman, Walberg, and Welch (69), Rothman (68), Orr and Young (59)] was identified as sharing a research emphasis. Although it is true that studies cited earlier in this paper also contained research components, their primary focus appeared to be evaluation of inservice programs and activities. Again, many of the studies cited in this portion of the paper used participants in the Academic Year Institute programs as their subjects.

Effects of Institute Participation

Roye (70) was interested in assessing those factors related to science and mathematics teaching which could be affected by attending an Academic Year Institute. He selected his population from participants attending institutes at Arizona State University during 1962-64. Information was gathered through the use of a questionnaire as well as from reading application forms and academic records of the participants. He found the majority of his subjects to be male, in their early 30's, with an average of 5-6 years of teaching experience. Fifty-eight of those who responded to Roye's questionnaire indicated that they had taken additional course work after completing their AYI program.

The respondents indicated that their experience had influenced changes which they had made in subject matter content they were using. Three major changes were (1) using new and different concepts, (2) using one of the new curricular approaches, and (3) greater depth and detail in subject matter content. In addition to changing the content they taught, many of the former participants were actively involved in science and mathematics curriculum development in their schools.

The teachers did not view themselves as having been greatly influenced in changing their teaching methods and procedures. Some felt more competent in lecturing and demonstrating. (Roye does not mention if any felt they had been influenced to increase the amount of laboratory activities included in their science courses.) The majority felt that the institute attendance had increased their ability to motivate their students' interest in science and mathematics. In general, the participants felt they had increased in subject matter preparation, competence, and enthusiasm.

Roye suggests that the optimum ratio of academic subject matter courses to teaching methods courses should be investigated to determine how best to increase the participants' competence and effectiveness as teachers. He does not, however, provide operational definitions for the terms "competence" and "effectiveness."

Bradberry (15) also examined the effects of institute attendance on participants. She concentrated on a population selected from different institutes during the years of 1959-60 and 1960-61. The six universities offering the institutes were all located in the Southeast. Principals as well as teachers were involved in this study.

Bradberry found that the teachers had revised the courses they taught, including more up-to-date subject matter. They had also made significant changes in their teaching methods by using more varied methods of presentation, emphasizing the problem-solving approach, using more textual and library material, and using more demonstrations in their science classes.

The teachers felt that institute attendance had benefitted them through broadened knowledge of subject matter, acquisition of new methods and techniques, development of self-confidence, and provision of opportunity for exchanging ideas with teachers in the same field. The principals indicated that these teachers were more enthusiastic about teaching science and/or mathematics than they had been prior to attending an institute.

Irby (40) surveyed individuals participating in the institute program at the University of Mississippi during 1961-66. He found that the teachers responding to his questionnaire felt they were more effective in the classroom because of their increased knowledge of subject matter. He concluded that the institute program does upgrade academic competency. However, he also pointed out the fact that teachers may be excluded from participation of their academic records do not provide evidence of graduate school potential. It would appear that the best academically prepared applicants are selected to participate rather than those teachers most in need of help. Furthermore, many of the participants shift from secondary to college teaching positions. Finally, institute programs serve only a small portion of the total teaching population. From these factors, Irby inferred that the contribution made by Institute programs was being minimized.

Dzara (22) investigated certain aspects of the chemistry section of summer institutes at the University of Alabama, 1957-62, from the point of view of the participants. He found that most of the teachers were inadequately prepared to teach either science or mathematics when they applied for admission to the programs. (It would appear these institutes did not use graduate school potential as a criterion for selecting the participants.) The teachers involved felt they had gained in subject matter and in knowledge of teaching techniques. The junior high school science teachers who responded to the questionnaire indicated that they wanted more direct guidance relating to what and how to teach, with emphasis on methods and techniques, rather than an increased knowledge of subject matter.

Menesini (50) conducted a study in which he attempted to relate certain changes that may have occurred in science teaching and curricula to attendance of teachers at NSF summer institutes. He used a questionnaire to obtain information regarding effects on (1) curriculum--new courses and subject matter changes, (2) participants--their teaching techniques and attitudes, and (3) other teachers--do the participants communicate with their colleagues? He concluded that the participants had changed their approaches to teaching as well as the subject matter content of their courses. There was an increase in the laboratory approach to science teaching among those who had attended summer institutes. Those who attended did share their newly acquired information with their colleagues. Menesini did not, however, attempt to determine if any changes could be found in pupil gains in achievement.

Teacher Characteristics

If inservice programs are to meet the needs of the teaching population, these needs must be identified. Shrader (76) conducted a study involving teachers with four years or less of teaching experience. The study was confined to teachers in Oregon and Washington. He found that 19 of the individuals responding to his questionnaire (total sample: 130) had neither a major nor a minor in science. Very few general science teachers had credit in earth science. Less than 50 percent of the biology, chemistry, and physics teachers in his sample had 27 or more credits in each science they were teaching. Many teachers had more than one preparation per day and indicated that they lacked adequate time and/or space in which to prepare for their teaching.

Nixon (57) studied physical science offerings, enrollments, and the preparation of physical science teachers in Alabama senior high schools, using the method of stratified random sampling. He found that the academic preparation of the physical science teachers varied with the size of the school, with the larger schools having the better prepared teachers. However, there were some teachers with minimal preparation in physical science in schools of all sizes, and a few teachers who had no background in physical science.

Nixon found that physical science teachers had made extensive use of the NSF institute programs to gain additional science content. He concluded that the level of academic training of Alabama's physical science teachers compared favorably with those of other states. However, few Alabama schools offered advanced courses in physical science. In addition, some small schools offered no physical science. This latter problem appears to be one requiring consolidation of school districts as well as a possible inservice program. Since Nixon found that larger schools attracted and hired better prepared teachers, consolidation should have doubly beneficial effects.

Orwick (60) was interested in determining the extent of participation of high school science teachers in NSF institute programs. He confined his search to high school teachers in a six county area around Raleigh, North Carolina. He found that 84 percent of his respondents were eligible for participation, 64 percent had participated, and 17 percent had applied but had not participated. He could discover no appreciable differences between applicants and nonapplicants with respect to their personal backgrounds and teaching experience. He did find that these groups differed in certain aspects of their academic background and professional activities. Applicants had more semester hours in undergraduate and graduate science than did nonapplicants, while the nonapplicants had more semester hours in education.

Jorgensen (42) studied the characteristics of teachers submitting applications to the AYI programs at Oregon State University. He considered all who had been accepted and randomly selected one-half of those who had been rejected as subjects for his study.

Individuals were compared on such factors as teaching residence, undergraduate science point average, undergraduate science credits, membership in professional organizations, teaching experience, etc. Jorgensen found that no specific characteristic discriminated consistently between acceptees and rejectees for each of the years included in his study. He also found that, in terms of recommendations for science teacher preparation as stated by the AAAS, many applicants were lacking in depth and breadth of preparation in science and mathematics.

Sarner and Edmund (72) also considered the individuals applying for institute programs. They confined their sample to those teachers applying for programs at

Temple University. They were interested in securing information they could use in answering three questions: (1) who are applicants for general science institutes, (2) what reasons are given for seeking admission, and (3) to what extent are the objectives of those individuals accepted for participation in the program satisfied?

Using a random sampling technique, they selected 114 names from a total of 1,400 applicants for the summers of 1959 and 1960. They found that 105 of the 114 were full time general science teachers. The most common reason for applying was to acquire more knowledge of content. Only eight percent of the sample were concerned with learning methodology. Almost 10 percent of the sample had had no courses in biology; 25 percent, no chemistry; 25 percent, no physics; approximately 50 percent, no earth science.

In order to answer the third question concerning the meeting of the teacher's objectives for applying, the investigators contacted 35 teachers who had completed an earth science institute in the summer of 1960. These teachers indicated that they had gained knowledge of content and had acquired confidence in teaching science as a result of the program.

Orr and Young (59), working with the American Institute for Research, conducted a study designed to obtain information about the characteristics of applicants and nonapplicants for NSF programs. They sought to obtain data concerning biographical information; training and education; professional activities; attitudes, needs and motivations; and relevant school and community characteristics. The study, begun in July,1961, was completed late in 1962. Both a questionnaire to teachers and an interview schedule were used. Using the method of stratified random sampling, 491 schools were chosen for the study.

The investigators found that of an estimated total of 169,000 mathematics and/or science teachers, approximately 32 percent had applied for and attended NSF programs, 13 percent had applied and been rejected, and 55 percent had never applied. Although the majority of the nonapplicants were in the public schools, proportionately more tended to come from nonpublic and junior high schools. There were more female than male nonapplicants. Nonapplicants tended to teach in rural rather than in urban school systems and in schools with less extensive course offerings in science and mathematics. They tended to feel that parents, students and surrounding community were less favorably inclined toward education and science than did the applicants.

Nonapplicants were likely to be teaching in at least one other subject-matter field as well as in science or mathematics. Since they spent less than 40 percent of their time teaching mathematics or science, many nonapplicants have primary identification with some other subject. In addition, the nonapplicants tended to be less subject-matter oriented. They apparently derive relatively greater satisfaction from their interpersonal relationships with students and relatively less from their subject-matter activities. They also engage in significantly fewer professional activities.

These and other findings were used by the investigators as the basis for their conclusion that failure to apply for NSF programs was often indicative of a generally low level of self-improvement motivation on the part of the teachers involved in the study.

Berger and Berger (6), working for Psychometrics Consultants, surveyed applicants to NSF summer institutes in 1964. The population included elementary school and college teachers as well as secondary school teachers. The 1964 program attracted more than 80,000 teachers who submitted approximately 200,000 applications.

Similar studies of secondary school teacher applicants had been made in 1957, by the Corporation for Economic and Industrial Research, and in 1960, by Science Research Associates. These studies were used for comparison purposes with the findings of the 1964 population.

A randomly selected sample of 4,400 secondary school institute applications was analyzed. An examination of these forms revealed that the number of undergraduate credits in physics and chemistry decreased significantly with each year. Graduate credits in each of the five sciences markedly increased from 1957 to 1964 for the applicants accepted for summer institutes. The percentage of undergraduate majors in education increased with each succeeding year, while the science or mathematics majors decreased. The percentage of applicants with the bachelor's degree as the highest degree increased each year. More applicants in 1964 than in 1960 had had recent experience teaching a combination of non-science subjects and science or mathematics. There were fewer applicants with provisional teaching certificates in 1964 than in 1960.

The trend for selection in all three surveys was to favor those teachers with the higher grades. In 1964, the higher the number of graduate credits in any subject, the greater the likelihood of being accepted for an institute program. In all three years selection tended to favor those with a science or mathematics undergraduate major. Professional interests, on the whole, did not seem to enter significantly into selection. Academic performance and a professional orientation toward science and mathematics appeared to form the strongest and most consistent criteria for selection in 1957, 1960, and 1964.

Another, but less-global, survey was that conducted by Barfield (3) in which he investigated the problems of beginning science teachers in Virginia high schools. He was interested in identifying (1) the extent of help needed by beginning science teachers in certain selected problem areas during their first semester of teaching, (2) the amount of help provided by persons available for assistance, and (3) the help which beginning science teachers recognized as being provided by certain selected inservice techniques during their first semester of teaching.

He found that secondary school science teachers beginning their teaching careers in 1958-59 recognized the need for help in certain selected problem areas. The responses to Barfield's questionnaire appeared to indicate that the foremost problem was that of locating instructional materials for teaching science. The teachers were of the opinion that much help should come from experienced coworkers.

The majority of the beginning teachers in Barfield's population were of the opinion that no one had helped them. Their supervisors, however, believed that adequate help had been provided. It would appear that there is need for better communication between all persons concerned with the supervision of new science teachers. It would also appear, if these findings are still valid, that inservice programs for beginning teachers may need to differ in emphasis and content from those designed for experienced teachers.

Teacher Attitudes, Behaviors

Many of the research studies cited thus far have been concerned with subject matter preparation. Another area which also deserves attention is that of the investigation of teacher behaviors and attitudes. Does increased subject matter knowledge contribute toward teacher effectiveness, however this term may be defined, if it still has to filter to the students through the same old teacher beliefs and behaviors?

Blankenship (10, 11) was interested in studying teachers' reactions to BSCS biology. Inferring that new programs may call for modification and/or radical changes in teaching techniques used by science teachers, Blankenship wished to determine teacher attitude toward these programs. He used four different methods to determine attitude and analyzed the effectiveness of each. The methods consisted of an attitude inventory which Blankenship devised, a peer rating, the instructor's rating, and a follow-up questionnaire designed to ascertain the use, lack of use, and anticipated use of BSCS programs.

Blankenship found that his attitude inventory and the peer rating were equally effective in identification of teachers' attitudes and that the instructor's rating was least accurate. In the questionnaire used in the study, he asked teachers to state reasons for the non-use of BSCS materials. He concluded that one cannot equate the number of teachers teaching a particular program with the number who agree with the program's rationale.

In classifying the teachers in his sample as having attitudes favorable, unfavorable, and not certain relative to BSCS, Blankenship concluded that teachers with favorable attitudes generally ranked higher on measures of capacity for independent thought and action and had taught high school biology fewer years, on the average, than those who did not favor BSCS.

Several investigators (68, 69) conducted studies of the teachers involved in the Harvard Project Physics program. Rothman, Walberg and Welch (69) were interested in (1) determining whether, as a result of participation in the institute, the teachers' attitudes towards physics and towards several activities related to the teaching of physics had changed and, if so, (2) identifying specific changes in attitude.

They used a randomly selected sample of 56 physics teachers from a national population of approximately 17,000. Thirty-six of these teachers participated in a summer institute and served as the experimental group while the remaining 20 were the control group. These two groups were asked to rate, in a post-test, each of a series of concepts (physics, physics in my life, doing laboratory experiments, solving problems, etc.) on a list of bipolar adjective scales (semantic differential technique).

The investigators found there was no overall significant group difference on the "student activities" scores and concluded that the teachers' attitudes concerning student activities apparently were not affected by the summer institute. They found, however, that the teachers in the experimental group rated science more understandable and physics in their lives as less complex. These teachers also rated science more important, but physics less important. From these findings, the investigators inferred that the factual content about science had apparently been presented in an effective manner. The broad approach which involved astronomy, chemistry, and technology as well as physics and which stressed the social implications of scientific progress rather than mathematical rigor was considered to account for the difference in rating of physics as compared to science.

The teachers in the experimental group also regarded the universe as less friendly. The investigators speculated that the teachers might feel threatened because they may have felt inadequately prepared to teach the astronomy unit. Despite this finding, the teachers who attended the institute exhibited generally favorable attitudes as compared with those of the control group. In addition, these attitudes seemed to reflect the objectives of the institute. The philosophy of the course is that physics should be seen in relation to other sciences, scientific processes, and to culture and modern life. The teachers in the experimental group did see science as more important and understandable and physics as correspondingly less important and less complex in everyday life, thus exhibiting attitudes which seemed to characterize a broadened view of physical concepts.

Rothman (68) continued to study the teachers in the experimental group. He was interested in determining whether the teachers' attitudes towards the same concepts changed while teaching the new course and, if so, to compare these changes with those that occurred while they attended the physics institute. He used the instrument developed for the post-test previously described, administering it in the middle of February in the year following the summer institute.

Rothman was particularly interested in determining if there were any significant changes in the teachers' attitudes towards the student activity variables included in the semantic differential instrument. He found that, after teaching the new course for five months, the teachers responded that "doing laboratory experiments" was more important and more orderly. They also rated "learning about science" as simpler and "solving physics problems" as simpler and more orderly. All significant changes in attitudes were in the positive direction. These results were in marked contrast to the finding, during the summer institute, of no overall attitude change towards these variables.

There were additional significant attitude changes. These, too, were in a positive direction. The teachers rated "science" as more understandable and "physics in their lives" as more important. They also found "physics" more interesting and safer. Although, during the institute, the teachers had rated "science" more important than "physics" this difference had disappeared. The teachers reacted favorably to both science and physics.

Rothman concluded that participation in a summer institute is only a preliminary factor in the forming of teacher attitudes toward a science course.

It would appear that only when teachers assume the role of teachers and operate in the reality of the classroom are they able to view the offerings of the course in proper perspective. In the frame of reference as teacher rather than as institute participant, the individuals can react to the effects of student activities and attempt to judge the suitability of the course content. As a result of teaching the course, the teachers become favorably disposed toward its concept of physics and toward the student activities it offers.

An inservice project involving the investigation of teacher behavior was reported at the National Science Teachers Association annual convention in Dallas, March, 1969 (80). Project PIBAC (Pupil Inquiry Behavior Analysis and Change) is being conducted in the Springfield, Missouri, Public Schools in an attempt to change the instructional behavior of high school biology teachers so that they promote increased student inquiry in their classrooms.

The project involves visits to the classrooms of the participating teachers, small group workshops conducted after school hours within each individual high school and weekly large group workshops. Data are recorded on videotape and these tapes are analyzed using several instruments: Flanders Interaction Analysis, specially designed PIBAR (Pupil Inquiry Behavior Analysis Record) and CEBAR (Cognition Elicited Behavior Analysis Record) instruments. The project is still in process. Results should be available in the near future, either from the Springfield School System or from the Mid-Continent Regional Educational Laboratory in Kansas City, Missouri, whose personnel are working with the Springfield teachers.

SUMMARY

Numerous reports and studies have been reviewed for this paper. They can be classified into four general groups: National Science Foundation institute programs, locally developed programs, cooperative college-school programs, and research and/or evaluative studies. Although inservice education may be thought of as having four broad goals: (1) skill training, (2) acquisition of information, (3) attitude change, and (4) general self-improvement. (2), the acquisition of information, appears to have received the most attention.

The task of attempting to analyze these goals in terms of inservice activities has proven a difficult one. It is easy to determine if a teacher has acquired information by administering an achievement test or a test battery. Determining attitude change is a more complex task although some progress has been made toward this objective in the form of studies such as those of the Harvard Project Physics investigators in which teacher attitude changes are inferred through the use of a semantic differential test. However, as was pointed out in Blankenship's study (10), the attitudes that teachers profess to possess and what goes on in their classrooms are not always comparable. Another factor that must be considered is that attitude change is a slow process and most of the inservice evaluative studies have not been longitudinal ones.

General self-improvement is a goal that appears to lend itself most readily to subjective evaluation. Many studies asked the teachers for their opinions regarding the benefits of participation in institute programs of differing types. The majority of responses in the studies indicated that teachers did feel that they had improved, not only in knowledge, but in enthusiasm and self-confidence as teachers. It would appear that general self-improvement is a side-benefit of many programs aimed at the acquisition of information by teachers.

The neglect of inservice programs emphasizing the objective of skill training is puzzling. Some studies contained reports of teachers learning to manipulate laboratory apparatus or of acquiring research techniques. However, if the use of educational hardware and the interpersonal relations aspects of teaching are to be considered as parts of skill training, little research has been reported in these areas.

In the introduction to this paper, eight problems were listed as factors contributing to the need for inservice education for secondary school science teachers. These were (1) rapid obsolescence of subject matter knowledge and skills, (2) the proliferation of educational hardware, (3) the fluid but apparently evolving state of learning and instructional theory, (4) the advent of new educational tasks, (5) a growing necessity for global awareness, (6) the acceleration of school reorganization, (7) the consequences of teacher misassignment, and (8) the problem of teacher drop-outs (66). Again, only the first of these problems appeared to be a consistent concern in the materials surveyed.

Goodlad, in "The Schools vs. Education," (31) said

> Public schooling is the only large-scale enterprise in this country that does not provide for systematic updating of the skills and abilities of its employees and for payment of the costs involved. Teachers are on their own as far as their inservice education is concerned, in an environment designed for 'telling' others, yet one that is grossly ill-suited to intellectual pursuits with peers. . .

If this is a valid criticism, as it appears to be, much work needs to be done to improve inservice education for science teachers as well as for teachers of the other content areas. It is difficult to consider inservice education apart from the broader framework of innovation and change. Historically, inservice education was developed to correct deficiencies of preservice education. It is still difficult to achieve both breadth and depth in undergraduate programs for science teachers.

Although many of the National Science Foundation Institute Programs appear to have been designed to improve knowledge and teaching methodology of the experienced classroom teacher, beginning teachers can also benefit from inservice education. A study cited earlier in this paper provided evidence that beginning teachers recognized the need for help in certain areas. The majority of the teachers were of the opinion that no help had been provided them. Beginning teachers have been described as suffering with the "Robinson Crusoe syndrome." Each individual works alone, in the usual teaching situation, and handles his class unaided, unvisited, and unobserved (54).

If isolation sets the context for the orientation of the beginning teacher, then it is not difficult to understand why many teachers might equate innovation and change with threats to their security and established routines. Introducing and using new ideas in the classroom involves a number of problems. Although much has been written about the resistance to new ideas and change that exists among school personnel, few studies reviewed for this paper were concerned with this problem. The assumption seemed to be that the benefits of new programs and/or inservice activities would be so obvious that they would outweigh all objections to their installation.

In addition to failure to consider possible opposition or resistance to change, many of the local programs surveyed appeared to result from a need that had been identified by one or more individuals within a school or school system. Some of these programs lacked a research base for the plan of action that was followed. Such a lack may result in a program that is not really appropriate. The program may treat the symptoms but never identify the cause and deal with it.

A study of inservice education programs in Nebraska secondary schools with 10-40 teachers (58) revealed that most of the teachers and administrators surveyed felt that their school's inservice program was inadequate. The three areas in which teachers most wanted help were (1) motivating students, (2) providing for individual differences, and (3) developing and using new approaches and innovations. The problems of beginning and experienced teachers did not differ greatly. Both groups indicated they had received very little help from inservice programs.

Systems which lack the personnel and expertise to develop good inservice programs should develop a working arrangement with some college or university. They might also establish contacts with one of the Regional Laboratories or with a Research and Development Center. The Far West Laboratory For Educational Research and Development (30) is involved in five major areas, one of which is teacher education at both the preservice and inservice levels. The personnel at the Laboratory are attempting to develop a series of inservice education packages, based on the findings of the Stanford Research and Development Center.

The Research and Development Center for Education at the University of Texas in Austin is also involved in inservice education. This emphasis resulted in "Designs for Inservice Education" edited by E. W. Bessent (7), a monograph in which three different approaches to inservice education are presented. These models (the laboratory approach, the classroom experience model, and the teaching demonstration model) were developed from work done by University personnel and various school districts. Inservice education, for the purposes of this publication, is defined as "all those planned staff development programs which are designed to bring about instructional improvement in schools." Summer school as an inservice activitiy is excluded from consideration.

Another source of information for supervisory personnel charged with the development of inservice programs is "A Sourcebook for Science Supervisors," (33). Published by the National Science Supervisors Association, a section of the National Science Teachers Association, it was developed to serve as a vehicle for the exchange of ideas and information among science supervisors.

Many individuals consider that inservice education and curriculum development are parallel activities. Only a small portion of the materials reviewed for this paper were reports of such projects. This appears to be an area in which more work needs to be done.

This may be an appropriate point at which to request that studies be reported in sufficient detail that they may be replicated. Frequently investigators report that different treatments were used but do not supply sufficient detail to ensure that replication is possible. Doctoral dissertations provide brief descriptions of the methods used to analyze the data obtained but these, too, are frequently too brief to ensure adequate replication.

A second request that might be made is that more of the local programs and inservice activities be written up and made available for public information. Reports sent to a center such as the ERIC Clearinghouse for Science Education can be processed and their existence made known through newsletters and bibliographies distributed from the Clearinghouse.

Local programs which are presently available for public information constitute only a small portion of the references cited in this paper. Those which were available tend to center around a specific subject or content area. Only a few might be classified as having a broad fields approach, such as that exemplified by outdoor education programs or by activities conducted at a science center. More work needs to be done in the area of unified science and more of that which has been done needs to be disseminated.

The inescapable conclusion regarding inservice education activities is that most are attempting to bring about the kind of learning resulting in change and improvement in teachers and in the courses they offer. The effectiveness of a program is judged by the degree to which learning has taken place. The attainment of such a goal often involves attitude change, yet most studies of attitude change were concluded before any long term effects became evident, a fact that was mentioned earlier. In addition, there is no simple one-to-one relationship between information, attitude and overt behavior (2).

These factors may account for the proliferation of studies that have been concerned with National Science Foundation institute programs. More than 16 investigators concentrated on one or more Academic Year Institute programs. Most of these investigators appeared to be aware of the fact that it is difficult to alter complex patterns of teacher behavior, even in a nine month period. Many of the studies were based on questionnaires and required the participants to analyze the benefits they felt they had gained from their experiences. Although the majority of the findings were positive, more research needs to be done to provide concrete, objective evidence of the effects of Institute participation by teachers on school programs.

Although NSF institutes have been a definite factor in improving the science teaching to which our students are exposed, they are not an ultimate panacea. The most significant finding of a study by the American Institute for Research, conducted during the 1961-1962 period, was that more than half of the secondary school science and mathematics teachers had not submitted an application to any institute during the previous five years (56).

This problem is also compounded by the fact that many of the teachers who do apply for institute programs are rejected because their undergraduate records are such that these individuals are unable to qualify for institutes in which they must also be admitted to graduate school. In such situations, it would appear that the good tend to become superior and the poor continue in mediocrity (56).

Yet another problem related to institute programs stems from the differences that often exist between so-called "institute courses" and the standard graduate program. A similar situation exists in preservice teacher education. Many of the advanced but undergraduate science courses are designed with the expectation that the students enrolled will pursue careers as research scientists rather than as science teachers. More research needs to be done to design graduate credit courses in the sciences that are appropriate to the needs of secondary school science teachers.

One of the common assumptions among educators is that the division between preservice and inservice education will disappear and that "continuing education" will become the focus of their efforts. This has not yet become an actuality. Kreigehbaum and Rawson (56) point out that the effect of institute programs on the undergraduate curriculum for preparing teachers has been less than the National Science Foundation originally hoped for and that those changes which have occurred have taken longer than expected. Unless beginning teachers are well-prepared to teach the subjects to which they are assigned, the institute programs will have to continue indefinitely. Although institute programs may help to alleviate the problem of lack of preparation, they are not an adequate substitute for an excellent undergraduate education.

This is not to imply that improving the preservice education of secondary school science teachers would eliminate the need for inservice education. This is far from reality. Changes in content, in teaching methodology, in knowledge of learning theory and instructional strategies, as well as new developments in educational technology and the concepts of differentiated staffing necessitate that inservice activities be one of the on-going components of the school program.

Surveys reveal that the average length of time that an individual remains in teaching continues to be about five years. This fact, coupled with the reality that preservice programs can provide teachers with only the basic skills of teaching, emphasizes the need for inservice programs. It has been suggested that one of the objectives of an inservice program should be to develop a cadre of "resource teachers" (7). Such individuals would be involved in the pilot program and could later serve as local consultants to new staff members. Presumably they would attain sufficient status and incentive in this role to encourage them to remain longer than the average five year period.

An area which appears to have received only a fraction of the attention it deserves is that of designing inservice programs for teachers who are teaching science to different cultural groups. Only one study was located in which this problem was considered.

If one overall generalization were to be made in summary of the literature reviewed for this paper, it would be that providing inservice education for science teachers is a vital problem that deserves more attention and careful research than it has thus far received.

RECOMMENDATIONS

The majority of the studies cited in this paper, if they have involved research at all, have been of the type of research categorized as descriptive. Some were status investigations; many were questionnaire surveys. One of the first recommendations that might be made is that a greater variety of research methods should be attempted in inservice education. There were a limited number of experimental research studies in which different treatments were applied to different groups. Pre- and post-treatment tests were administered to these groups and the data were used to determine the differential effects of the treatments. Such studies are infrequent occurrences in inservice education, however. Perhaps educators feel that if a treatment (program, activity, new course of study) is going to benefit the subjects involved, it should not be withheld from the total population merely for comparison purposes. The assumption that the implementation of an untested program will prove beneficial is open to question.

Another type of research study, commonly known as "action-research," was not much in evidence in the literature either. This term possesses a variety of definitions and is used here to refer to research studies which take place within the context of the regular school program and which are carried out by the school personnel normally involved in the program. Such studies may entail a change in teaching methodology, instructional theory, or content, to name a few examples. These studies have also been subject to criticism by educational researchers because many did not, in the opinion of the researchers, meet all of their criteria for research. Nevertheless, if school personnel can secure help in designing and initiating action-research studies, these would be of benefit to the systems involved.

The suggestions or recommendations which follow are concerned with the topics of (1) the development of local inservice programs, (2) teacher attitudes, behavior, characteristics, (3) other areas in need of research, and (4) research design and evaluation. The statements are descriptive rather than prescriptive. Questions are raised for consideration rather than as demands for immediate action.

Local Inservice Programs

One of the major criticisms of inservice work is that many of the programs have been planned by sources removed from the local situation. New curriculum materials have to be implemented by people who did not originate them. If these materials are to be used properly, the teachers need to know (1) what to do in terms of both content and the instructional strategies, (2) how to do it, to implement the strategies involved, and (3) why to do it that way (18).

Inservice activities should be locally initiated and developed. This does not imply that programs developed by the national course content improvement projects or by publishing companies are not of value. Individuals participating in the development of new curricula contribute expertise and perspectives far beyond those an individual school system or district is able to command. Nevertheless, this broad approach must be redefined and focused on problems existing at the local level if any real and lasting improvement is to occur.

This means that individuals responsible for structuring and initiating inservice education activities must have a broad background in inservice education per se as well as in the content area(s) involved. Several sources of information are available to those wishing to attain this perspective. One is a document entitled "Inservice Education--Psychological Perspectives" (2). Written by James J. Asher for the Far West Laboratory for Educational Research and Development, it is a report summarizing and evaluating literature and research relevant to inservice education and dealing with the psychological settings for behavioral change.

Asher's report is divided into seven parts: (1) the history of inservice education, (2) the ideal goals of inservice training, (3) the analysis of inservice programs that have been tried, (4) 'the acceptance of innovation,' dealing with the question of resistance to new ideas, (5) the evaluation of inservice programs, (6) future inservice programs, and (7) recommendations.

An even more extensive survey of literature was also prepared for the Far West Laboratory by Dorothy Westby-Gibson for her report, "Inservice Education--Perspectives for Education" (84). She included a 184 item bibliography which covers newspaper articles, journals, books, and other materials published from 1950-1967. The topics included in this report cover new practices and devices such as (1) systems analysis, (2) interaction analysis, (3) microteaching, (4) sensitivity training, (5) various electronic media, and (6) the diversification of staff and duties.

A third source of information is the Guba-Clark Classification Schema of Processes Related to and Necessary for Change in Education (20). In this model the developers explain the phases they consider to be involved in initiating change in education. These phases may be categorized as research, development, diffusion, and adoption.

These sources, plus selected chapters in Innovation in Education, edited by Matthew B. Miles (52), can serve to provide a background for considering inservice education activities. In Chapter 10, the strategies used in developing and disseminating the Physical Science Study Committee's high school physics course are discussed. Although the task facing the PSSC personnel was one with nationwide aspects, many of the methods they used can be adapted to local programs and activities.

Introducing and using new ideas in the classroom involves a number of problems. Research needs to be done to determine what methods work best for a particular school or school system. The three models suggested in an earlier part of this paper: the laboratory approach, the classroom experience model, and the teaching demonstration model should be investigated and compared to determine which meets with the most success and in which situations it can be used most successfully. More importantly, perhaps, other models can be developed and tested.

More attention should be devoted to inservice programs that attempt to articulate the science program within a total school system, K-12. Is there a consistent approach and philosophy throughout the student's educational experience in science? Does he function in the inquiry mode in elementary school only to be confronted by textbook-oriented science in the secondary school or science courses dominated by the objective of college preparation? Or, does his elementary science experience consist primarily of reading about science rather than doing science so that he is ill-prepared for any secondary school science course in which he is expected to demonstrate that he already possesses a command of the processes of science and can use them as an independent investigator?

The problem of obtaining qualified personnel to guide the development of an inservice program persists. Outside consultants, on a short term basis or in some continuing liaison with the school system, may be obtained for the initial stages of development. Research needs to be done to determine methods which may be used to develop personnel within the school system who are competent to function after the consultants leave or who can work unaided by outside experts.

Finding time for inservice activities apparently has always been a problem. Teachers are not at the peak of enthusiasm at 4 P.M. on a school day. An inservice program, in order to achieve maximum effectiveness, should be built into the school day. Provision must be made for released time for those teachers involved in development and inservice activities. An alternative solution would be to pay the teachers for inservice participation, either with additional cash or credits toward the next salary increment. Either plan requires money, for the substitute who takes charge of the class or for the teacher involved in inservice. Research needs to be done to determine what plan works best for a particular school, both in terms of teacher acceptance and in terms of actual change evidenced in the classroom. Still other approaches to the time problem need to be devised and studied.

If one school system is unable to muster adequate finances and personnel to carry out inservice education, the possibility of developing regional centers which could serve as loci for inservice activities and materials development should be investigated. Some examples already exist, such as the Science and Mathematics Improvement Project in Wilkes-Barre, Pennsylvania, and the Pacific Science Center, Seattle, Washington (74, 62). Such regional centers could be assisted, at least in the initial stages, by personnel from the various Regional Laboratories and by members of science education faculties from a local college or university. Such a consortium of school districts should be more effective in attacking common problems than each system working independently would be.

If inservice education at local, county, state or national levels is to be successful and productive, the factors of time, finances, personnel, and appropriateness must be considered. A common conclusion about effective inservice programs appears to be that they involve released time, require special instructional materials (in many cases), make appropriate use of outside consultants, and demand adequate commitment of supervisory and administrative time to the program.

Teacher Attitudes, Behaviors, Characteristics

More research needs to be done in the areas of teacher attitudes, behaviors, and characteristics. Many of the studies concerned with National Science Foundation Institutes reported on teacher characteristics. However, fewer investigators considered teacher attitudes and behaviors to be a part of inservice education research. If it is true that resistance to change and to new ideas exists among school personnel, research needs to be done to determine the degree to which this resistance exists. Is it more imaginary than real? What factors might account for it, if resistance does exist? How can new ideas and methods be introduced without having the teachers feel threatened?

Does the degree of acceptance of a new program or other innovation involving inservice work vary with the number of individuals initially involved in design and implementation? Studies concerned with this question have been done at the elementary level but none were located that involved secondary school science teachers.

Is the verbalized philosophy of classroom teachers consistent with the teaching strategies employed in their classrooms? If we accept the assumption that "teachers teach as they are taught," should teachers about to adopt new curriculum materials which involve new teaching methodology experience the course in the same way that their students will experience it? Will such a treatment guarantee that the changes will be in evidence in the classroom? How can we find out?

Follow up studies need to be done to determine what changes in teaching are really made by individuals who have been exposed to inservice activities as well as to investigate the effects of time on these changes. Can inservice programs be designed that enable a teacher to become a flexible, innovative person in the classroom? Should beginning and experienced teachers receive the same type of inservice program to prepare them for a new curriculum? If the programs should differ, in what ways should they vary?

Research also needs to be done to determine what types of inservice programs are most effective in helping teachers attack the problem of attitude change. Should such programs be concentrated in a six week summer program or, since attitude change is a long process, should the activities be spread throughout the school year? What types of activities work best with science teachers? Do experiences which help science teachers examine themselves and their teaching methods objectively differ from those which achieve success with teachers in other subject areas?

In inservice as well as in preservice education for secondary school science teachers, the emphasis has been placed on enabling the individuals to increase their science content knowledge. Studies reviewed for a review of research relative to preservice education (12) tended to support the assumption that more than an adequate knowledge of science was necessary for an individual to function effectively in the classroom. Investigators have found that teachers categorized as "nonapplicants" for institute programs derived relatively greater satisfaction from their interpersonal relationships with students and relatively less from their subject-matter activities. One might infer from this statement that the converse situation was the desirable one. Can this inference be supported by research? Should we develop inservice programs in which secondary school science teachers are enabled to participate in intensive group experiences? Should we limit their sensitization processes to microteaching and interaction analysis? How can science teachers be made more aware of the various forms of student feedback other than laboratory reports and projects? What types of programs should be designed? How should their effectiveness be evaluated?

Other Areas in Need of Research

Many studies involved institute programs. The majority of studies reveiwed teacher characteristics and the subjective judgments of the participants as to the value of their experiences. More research needs to be done to provide concrete evidence of the effects of Institute participation on school programs.

Follow up studies need to be done to determine what long-range effects, if any, result from Institute attendance. Additional studies should be done to determine how many AYI participants leave teaching and to identify the reasons for leaving.

More studies need to be done to discover the effects on the students of the teacher's participation in inservice programs, particularly of the institute variety. If they participate in an Academic Year Institute, the teachers are removed from the classroom and its problems for nine months. Many of the participants report, on returning to teaching, an increase in enthusiasm. What happens to this enthusiasm as time passes? Especially, what happens when the teacher is the only member of his department with these enthusiasms and interests? Such a situation has been compared to the transplant of some foreign tissue to the body. The tissue is rejected. Does this "rejected" teacher conform to the predominant teaching pattern of his department, does he try to convert his colleagues, does he move to a new school where his views are shared, does he return to graduate school, does he leave the teaching profession? Such a problem lends itself to case studies as well as to the conventional questionnaire study.

More studies need to be done in which the teaching of former AYI participants is compared to that of control groups. Also, does participation in several summer institute programs provide benefits commensurate with that of being a student for an entire academic year? It might also be worthwhile to conduct a national study of the effects of Academic Year Institute attendance on science teaching.

As yet no research has been made available in which any attempt has been made to develop a model institute program. It is likely that one model would be inadequate; probably several "model programs" should be developed.

More studies need to be done in which the primary investigation is that of measuring changes in participant understandings rather than determining satisfactions and dissatisfactions.

Another problem that does not appear to have been investigated, perhaps because a suitable means of investigation is not apparent, is that of determining the effectiveness of teachers prior to participation in institute programs. Some of the reports indicate that those teachers who apply for institute programs are already categorized as effective teachers by some standards.

A concomitant problem can be identified as that of the science teachers who might be termed "nonapplicants" insofar as institute programs are concerned. What can be done to reach these individuals? Are they as much in need of these experiences as some science educators have inferred?

What can be done about another group, that of the science teachers who need to gain more content knowledge but who cannot meet the standards set for any of the different levels of institute programs? Chances are that such individuals are in school systems too small or too inadequately financed to have their needs met through a local inservice program. How are they, and the pupils in their classrooms, to be helped?

Another area in need of more research is that of designing inservice programs aimed at educating teachers so that they present science as a way of thought rather than as a body of content to be learned. Some of the investigations involved in the Harvard Project Physics program have emphasized this problem but more work needs to be done.

More research needs to be done on the adoption, acceptance, and implementation of the new curriculum projects of both the federally-funded and commercial variety. Investigators need to design measures for determining the understanding by the classroom teachers of the philosophy and rationale of the program they are adopting. Research needs to be done to determine if the teachers can demonstrate this understanding in their teaching behavior. Studies cited in this paper have revealed that what a teacher says he believes and what he practices in the classroom are not necessarily identical. Can reasons for the existence of this incongruity be identified? Do the reasons lie within the teacher or within the situation in which he operates? What can be done to change the situation?

An area which appears to have received only a fraction of the attention it deserves is that of designing inservice programs for teachers who are teaching science to different cultural groups. Should science teaching for bicultural groups be different from either what we have traditionally been teaching or the newer curriculum projects? Is science for the inner city secondary school student necessarily different in content and approach than science for the suburban or rural students? If so, what needs to be done to prepare experienced, as well as beginning, teachers to function effectively in their assignments? What new methodologies need to be developed and used? How can this best be accomplished?

New materials and teaching tools continue to be developed. How can inservice programs prepare science teachers for the multi-media approach to education? What should be done to make them competent to evaluate and use the many pieces of educational hardware now on the market? What are the most efficient ways to help science teachers use television, videotaping, programed instruction, etc. in their classrooms?

Research also needs to be done on the problem of providing for continuing inservice education. Presently, inservice activities seem to come in short spurts or to take place in locations removed from the actual school setting in which the teachers operate. More research needs to be done in designing programs of the Cooperative College-School variety. Both classroom teachers and college faculty benefit from these programs. The college teachers can provide knowledge and perspectives that classroom teachers have been unable to develop due to the press of routine duties that are a part of public school teaching. The classroom teachers, in turn, can provide the college staff with an opportunity to contrast practice with theory and to translate theory into action.

Research also needs to be done to determine ways of providing continuity for a program in which the personnel are changing. If the average tenure of an individual in teaching is three to five years, should programs be developed that run in three year cycles? How can inservice programs be designed to promote this continuity while also promoting the idea that innovation and change are necessary and desirable in education? Schools have been said to be resistant to change because they were established to transmit "the culture." Does what constitutes "the culture" in science teaching change over time? If it does, how can we prepare teachers to recognize and act upon this fact?

Research Design and Evaluation

Much of the literature reviewed for this paper entitled a "review of research" cannot be strictly classified as research. Doctoral dissertations were in evidence but many other documents were reports rather than research studies. There is need for more investigations of inservice education that merit the title of "research."

In some instances the problem investigated was a relatively trivial one. In other studies, a simple design was used to study a complex problem. In many, the description of the procedures used was lacking in detail and would make replication difficult if not impossible. Frequently variables that appeared to be relevant to the major problem of the study were not considered or received little consideration.

Although the recommendation has been made that more experimental research needs to be done in inservice programs, experimental research, too, has its disadvantages. It is useful in making end-of-the-project judgments but requires that conditions be held constant throughout the duration of the project if these judgments are to be valid ones. Frequently the need to make decisions and changes while the project is underway exists.

A research model known as the CIPP model (61) needs to be put to greater use in inservice education in those instances in which the project personnel wish to evaluate their work before completing it. This model was developed for use in evaluating innovative projects developed under Title III. It enables local project personnel to collect evaluative information that might form the basis for decisions.

The CIPP model is divided into four parts, reflecting the four major types of decisions which should be made during the course of the project: (1) context, (2) input, (3) process, (4) product. Each part can, however, stand by itself.

A modification of the CIPP model, called the CDPP model, has phases which consist of (1) context evaluation, (2) design evaluation, (3) process evaluation, and (4) product evaluation (65). This was developed as an adaptation of the Stufflebeam CIPP model by personnel at the Southwest Educational Development Laboratory.

Even if those individuals involved with the design of inservice programs at the local level do not wish to use either of these or any other models, they should make an effort to define the specific objectives of their program. This is not an advocation of the unqualified adoption of the behavioral objective approach. However, an objective such as "The teachers involved in this program will, at the end of six weeks, be able to identify the types of verbal and nonverbal reinforcement they use in their teaching" certainly provides more direction than a statement to the effect that "the teachers will attempt to become more effective in their interpersonal relations in the classroom and laboratory." Stating objectives in behavioral terms enables the individuals involved to better determine if these objectives have been reached. Overall objectives may be stated in global terms in order to provide a general framework. These can be broken down into more specific statements so that the teachers realize just what it is that they are expected to accomplish. More work needs to be done in this area, particularly with inservice activities relating to teacher attitudes.

In Conclusion

The present state of research in inservice education is not definitive enough to provide a basis for mandating inservice education practices for secondary school science teachers. It is hoped, however, that this paper will serve as a contribution to the profession through the identification of some sources of information, the citation of recent studies which have been done, and the summarization of some of the problems involved in developing inservice education programs for secondary school science teachers.

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ADDENDUM

For the convenience of those readers wishing a quick reference to materials reviewed for this paper, these materials have been categorized relative to the three main areas of the report: (1) program descriptions, (2) evaluation of inservice activities, and (3) research studies and reports. Some overlapping of areas two and three was inevitable because many studies included a research component in the evaluative investigation or an evaluative component in the research design.

Materials listed include not only those cited in the body of the paper but also related references listed in the latter part of the bibliography:

I PROGRAM DESCRIPTIONS: 4, 5, 8, 14, 17, 21, 25, 30, 38, 43, 45, 49, 51, 55, 62, 64, 71, 73, 78, 87, 96, 99, 101, 114;

II EVALUATION: 1, 6, 13, 16, 26, 27, 28, 32, 37, 39, 41, 48, 53, 56, 61, 65, 75, 77, 81, 82, 83, 85, 110, 115;

III RESEARCH STUDIES AND REPORTS: 3, 6, 10, 11, 15, 16, 22, 32, 39, 40, 42, 47, 48, 50, 57, 58, 59, 60, 68, 69, 70, 72, 76, 80, 90, 91, 104, 111, 118.